AN INVESTIGATION OF WATER QUALITY CHARACTERISTICS OF UPPER KAFUBU RIVER IN NDOLA, ZAMBIA

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APPROVAL

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To my beloved husband Nkaka and my daughters Mutale and Tsitsi

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ABSTRACT

This study analysed the physico-chemical and bacteriological characteristics of water in the Upper Kafubu River basin in terms of temporal and spatial variations in the period 1991-1999. The effects of urban activities on the physico-chemical and bacteriological regimes of the Kafubu River in Ndola were also assessed. The studied Kafubu River basin is 60 km^2 in size and originates from the Zambezi-Congo watershed. Analysed data included archival water quality data for sampling stations operated by the Ndola City council, water level and discharge data for Kafubu River, supplied by Water Affairs and rainfall measurements from Ndola Airport rainfall station. These data were supplemented by field measurements in the 1998/1999 season. Six sampling points were located along the whole stretch of the urbanised reach of Upper Kafubu River over distance of about 20 km from Itawa Swamps Railway Bridge in the northeast to Kafubu Dam in the southwest. Physico-chemical characteristics were determined by standard laboratory techniques at Kanini and Indeni laboratories in Ndola. Parameters analysed included temperature, colour, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), turbidity, taste, odour, conductivity, pH, total alkalinity, total hardness, calcium and magnesium hardness, chlorides, and Chemical Oxygen Demand (COD).

The results of analysis showed that, crude and minimally treated municipal and industrial effluents from sewage treatment plants and industries grossly polluted the Upper portion of Kafubu River. This was evidenced by high mineralization of river water such that TDS values averaged between 218.7 to 326.35 ppm, average conductivity (328.0 to 491.88 μmhos/cm), average pH of between 7.2 and 8.96 units, average total alkalinity and hardness of between 152.2 to 259.04 ppm and 133.28 to 294.88 ppm, respectively, were recorded. Trace metal concentrations that included lead (0.035 to 1.58 ppm) zinc (0.03 to 1.0 ppm) and copper (0.02 to 0.34 ppm) with lead exceeding the maximum allowable limit of 0.5 ppm in river water, were observed. Anion and cation transport were highest in the upstream stations at Itawa Swamps and Itawa Dam, which probably resulted from increased chemical decomposition and runoff associated with rain events such that solute transport was more pronounced during wet (November to March) than dry season (April to October). In contrast, the concentration levels of suspended

sediment concentration (SSC), chemical oxygen demand (COD), turbidity, colour, taste and odour were typically highest in the downstream stations (ST4 and ST5) and were more pronounced during dry season (April to October). Concentration levels of lead colour, pH, and at times SSC, turbidity, taste and odour were above ECZ (1993) maximum permissible levels for streams receiving wastewaters. The concentration levels of parameters such as TDS, conductivity, total hardness and alkalinity, calcium and magnesium hardness, copper and zinc were relatively high though within permissible levels for an effluent receiving stream used for subsequent production of drinking water. Similarly, the quality of treated water in terms of lead, colour, taste and odour, and at times turbidity, TSS and alkalinity concentration levels at both Itawa and Kafubu water works were above maximum allowable levels. Raw and treated river water in the Upper Kafubu catchment was alkaline and hard throughout the study period.

Organic pollution was evident with high chemical oxygen demand (COD) (39.73 to 65.66 ppm) in river water and also with the occurrence of high number of coliform bacteria (0 to 18 / 100 mls) and the presence of *E. coli* in treated water. The total coliform organisms and *E.coli* were present in most of the treated water samples at both water works indicating that tap water had pathogens which could cause health risks to consumers of this water. This was because chemical additive dosage levels used were insufficient for effective water treatment. Thus, it was deduced that non-continuous granular chlorine additive dosage and the low aluminum sulphate and the copper sulphate dosage, contributed to the presence of coliform bacteria and *E.coli*, excessive colour, and bad taste. The obsolete infrastructure, such as clogged sand filters contributed to the unwholesomeness of tap water especially at Kafubu Water Works.

It is concluded that a combination of temporal, spatial, hydrological and climatological factors control variations in water quality of Upper Kafubu River basin in a complex fashion. Therefore, with more data, multivariate analysis of the aforementioned factors should greatly improve prediction of river quality in Upper Kafubu River basin.

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